WE

instruction
manual

DV Meter

type **500**

MP MASTER
MA24474
-124

Weir Electronics Limited

DURBAN ROAD · BOGNOR REGIS · SUSSEX · ENGLAND

D V Meter

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CONTENTS

		Page Numbers
PART 1	INTRODUCTION	1
PART 2	SPECIFICATION	1
PART 3	OPERATING INSTRUCTIONS	
	Initial Adjustments	2
	Control Functions	3
	Operating Sequence	3
	Operating Notes	4
PART 4	TECHNICAL DESCRIPTION	
	Principles of Operation	4
	The Switch and Neon Circuits	5
	The Operational Amplifier Circuit	6
	Voltage to Number Converter	6
	The Decade Counter Board	7
	The Power Supplies	8
PART 5	MAINTENANCE	
	General	8
	Dismantling Procedure	9
	Setting-up Procedure	9
	Fault Finding Procedures	10
PART 6	PARTS LIST	11

LIST OF ILLUSTRATIONS

Fig. 1.	Block Schematic	5
Fig. 2.	Switch and Neon Circuit Diagram	15
Fig. 3.	Switch and Neon Layout Diagram	16
Fig. 4.	Amplifier Circuit Diagram	17
Fig. 5.	V-N Converter Circuit Diagram	18
Fig. 6.	Amplifier and V-N Converter Layout Diagram	19
Fig. 7.	Decade Board Circuit Diagram	20
Fig. 8.	Decade Board Layout Diagram	21
Fig. 9.	Power Supplies Circuit Diagram	22
Fig. 10.	Power Supplies Layout Diagram	23

1. INTRODUCTION

The DV Meter Type 500 has been designed to a 'value for money' philosophy to give a high performance/cost ratio. The novel circuits employ readily available components mounted on printed wiring boards to give high operational reliability. The number of preset controls has been reduced to a minimum to simplify setting up and test procedures and thereby minimise manufacturing costs.

The Digital Voltmeter consists of a voltage-to-number converter driving decade counters. The problems of stability in the voltage-to-number converter have been overcome by employing similar circuits for timing and voltage-to-frequency conversion, and these circuits are coupled both thermally and electrically so that any drift in one will be reflected in the other. Thus, the relative drift is extremely small.

The input voltage to be measured is first applied through an attenuator to a transistor-chopper operational amplifier which gives high common mode rejection and high input impedance. The output from the amplifier is a current proportional to the input voltage, and this is used as the charging current for an integrating circuit which produces a number of output pulses proportional to the voltage being measured. These pulses are then counted in a three decade counter, and the carry from the most significant decade operates a single digit display to give the instrument an overall range from zero to 1090.

The instrument is small, light and portable. It is robustly built and protected against overload up to 1000 volts on the input terminals. It will therefore be eminently suitable for use in schools and colleges as well as in laboratories and production test departments. The instrument is contained in an aluminium case clad with light fawn p.v.c. and the front panel and front trim are of satin anodised aluminium.

2. SPECIFICATION

Ranges (Push button selected)

Range	Sensitivity	Input Resistance	
0-1·090V	1mV	1MΩ	±2%
0-10·90V	10mV	10MΩ	
0-109·0V	100mV	10MΩ	
0-1090V	1V	10MΩ	

Any range may be specially scaled by adding one external resistor of appropriate value.

Accuracy

±0·1% of full scale ±0·2% of reading

± one least significant digit held with mains supply variations over +6% to −12%

Calibration

The internal calibration voltage is derived from a low temperature coefficient zener diode having a stability of ±0·001% per year at normal temperatures.

Temperature Range (Ambient)

0° to 50°C Storage
+10° to 35°C Operating
Warm-up time 30 mins for maximum accuracy

Attenuators

Attenuation ratio accurate to ±0·05% at normal ambient temperatures. Long term stability 0·025%. An internal preset trimming potentiometer is used to offset this drift by comparison with an external voltage standard. Metal oxide attenuator resistors are employed, having a temperature coefficient of <50PPM/°C.

Common Mode Rejection

With 1KΩ unbalance in either lead

dc	>60dB
ac 50Hz	>55dB

Maximum common mode voltage to chassis should not exceed 1000 volts peak.

Series Mode Rejection

ac50Hz >36dB

Input

The input circuit is isolated from chassis by >100MΩ and 100pF from either terminal to ground.

Input Overload

Voltages up to 1000V dc will not damage the instrument irrespective of the range in use.

Input Polarity

Polarity may be reversed by a push button switch, which also operates the positive terminal neon indicator lamps.

Operating Modes

Reading repetition rate variable from a maximum rate of 3 per second to infinity. 'Single Shot' and 'Hold' measurement is effected by use of the 't' control. Maximum digitising time <250mS.

Readout Display

Four windows comprising three neon decade number tubes with associated neon lamp decimal point indicators preceded by a neon figure '1' lamp.
A polarised light filter eliminates reflection and enhances the display contrast in high ambient light conditions.

Power Unit

Selected Transformer Taps:

110V	+6 −12%	50-60Hz	20W
115V	+6 −12%	50-60Hz	20W
220V	+6 −12%	50-60Hz	20W
240V	+6 −12%	50-60Hz	20W

The supply is fed via a captive three core cable. A 0·5amp fuse is fitted in the supply line.

Dimensions

10·5" wide x 3·75" high x 13·25" deep (26·7 x 8·6 x 33·7cm)

Weight

6lbs (2·7kg)

Finish

Light fawn p.v.c. clad aluminium with satin anodised aluminium trim and front panel.

3. OPERATING INSTRUCTIONS

Initial Adjustments

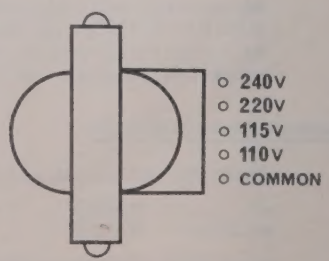
a)Transformer Tap Selection.

The instrument is normally dispatched with the power transformer tappings adjusted for 240V ac supply. If this does not suit the local line voltage, the wiring to the transformer must be modified.

Remove the top case assembly and the power supply board as described in Section 5.

Rewire the transformer tappings to suit the local line voltage.

Replace the power supply board and top case assembly.



b) Power Plug.

A suitable power plug must be fitted to the instrument power cable. The wires are colour coded as follows:
Red-Line; Black-Neutral; Green-Ground.

Control Functions

a) General.

The control adjustments described in the ensuing paragraphs should not be attempted until the instrument has been switched on for 30 minutes to reach thermal stability. (see Operating Sequence, below).

b) 'Set 005'

The preset 'Set 005' control is provided to compensate for any small drifts which may occur while the digital voltmeter is being used. The mode is selected by pushing the right hand push button, and the correction is made by adjusting the screwdriver control immediately below the button until the display indication is 005.

c) 'Set 912'

The preset 'Set 912' is provided to permit the voltmeter accuracy to be checked and, if necessary, reset at the commencement of each set of readings. The left hand push button marked 'Set 912' is pressed and the screwdriver control below it is adjusted until the digital display indication equals the number engraved against the control.
NOTE: The number given in the text above is typical, but a different number, depending on the internal zener reference voltage will be found on each instrument.

d) Range Controls

The range controls are the four push buttons in a vertical line immediately to the left of the display. They set the sensitivity of the instrument and determine the maximum voltage which may be displayed. The range selected is indicated automatically by the position of the decimal point in the display.

e) Input Terminals

The signal to be measured is connected to the input terminals at the bottom of the control panel. The positive side of the voltage being measured should connect to the positive terminal, which is indicated by a glowing neon situated immediately above the terminal. The polarity of the input terminals may be reversed by pressing the polarity button, which is the centre one of three situated above the terminals.

f) Sampling Time 't'

The digital voltmeter samples the voltage to be measured repetitively and displays the result for the period between samples. The repetition rate is sufficiently slow to ensure a readable display, but if there is any fluctuation of the input voltage, instability of the last digit may occur. This may be restricted by slowing down the sampling time, or in the ultimate, restricting to one sample only. In this condition, with the sampling time control 't' turned to the left, the voltmeter takes one measurement only and displays the result until the sampling time control is returned to a position giving repetitive sampling.

Operating Sequence

This information is provided as a guide to users who are unfamiliar with digital instruments.

a) Connect the instrument to the ac supply line and allow it to warm up for 30 minutes to reach thermal stability.

b) Turn the sampling time control 't' from left to right to initiate a reading.

c) Select the range required, and when in doubt, select a range less sensitive than the one required.

d) Push the 'Set 005' button and check that the indication is 005; if necessary, adjust the preset control.

e) Press the 'Set 912' button and check that the reading corresponds with the figure on the front panel below the 'Set 912' button; if necessary, adjust the preset control.

f) Connect the voltage to be measured to the input terminals and observe the reading on the digital display; if the reading is less than 108 in the last three windows, select the next most sensitive range.

g) If the reading remains all at zero, reverse the polarity of the input terminals by pushing the 'polarity' button.

h) If the reading is 1090, select the next less sensitive range.

Operating Notes

When operating on the most sensitive range of the instrument, the extreme right hand digit will change for changes of input voltage as small as 1 millivolt. Special precautions must therefore be taken to ensure stable readings on this range. The measured voltage must be firmly connected to the instrument.

When long leads are used to connect the voltmeter to the voltage being measured, interference voltages may be introduced in both leads; this is termed common mode interference and the voltmeter will provide automatic rejection up to 60dB of dc common mode signal. This means that on the one volt range, one volt of common mode interference will introduce an error of less than one digit in the most sensitive window, i.e. 1 millivolt.

Interference signals may also be introduced into one signal line only, so that they appear in series with the signal to be measured. This is called series mode interference and input filtering, combined with the chopping frequency of the dc amplifier, will give 36dB of series mode rejection to 50Hz signals.

When sudden large changes of input voltage occur, and when 'Set 005' and 'Set 912' adjustments are made, the display may take several seconds to reach a stable reading. Adequate time should be allowed before the reading is recorded or a further adjustment made.

When measuring signals from thermocouples, resistance thermometers, and other forms of transducer, it may be desirable to scale the output reading directly to the parameter being measured. This may be done by inserting an accurate attenuating resistor in series with the input terminal of the voltmeter, so that the input signal to the ranging resistor is attenuated to a suitable level.
e.g. If the output from the transducer is 13 volts for a load of 10lbs, insert a 3MΩ resistor in series with the input voltage. Then at full load on the transducer, the input voltage will be attenuated to 10 volts at the input terminals of the instrument, which will indicate directly in pounds weight.

While this method can be used for scaling the instrument, it does not provide linearisation and any non-linearities in the transducer law will exist in the voltmeter readings.

4. TECHNICAL DESCRIPTION

Principles of Operation

The block diagram, Fig. 1, shows the method of operation of this instrument. The voltage to be measured is converted to a number of pulses, the pulse repetition frequency being proportional to the input signal. These pulses are counted for a period determined by a timing circuit and the final count is shown on the digital display.

In similar instruments, great care has to be taken to obtain accuracy and stability in both the voltage-to-frequency converter and the timing circuit. However, in this instrument, both circuits are of the same basic configuration and are closely coupled both thermally and electrically so that any variations in ambient temperature, or in supply rails, will have an equal effect on both circuits. Thus, although the individual stabilities of the two circuits are not high, their relative stability is excellent, permitting an outstanding performance from this low cost instrument.

The input signal enters the instrument through an attenuator operating in decade steps. This signal is passed through a dc operational amplifier which provides a constant current, proportional to the input voltage, for the voltage-to-number converter. Negative feedback around the dc amplifier ensures its stability and an offset voltage fed to its summing junction permits the zero of the instrument to be set. Pulses from the voltage-to-number converter drive three decade counters in cascade and the outputs from the counter drive the digital display directly.

The sampling sequence is as follows: An output from the sampling generator triggers the gate bistable which removes inhibit signals from the voltage-to-number converter and from the timing circuit. Pulses from the voltage-to-number converter than pass to the counter, and

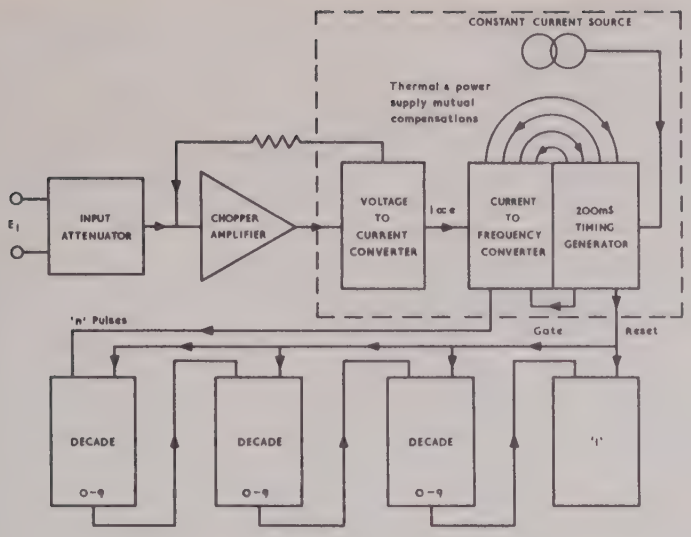


Fig. 1. Block Schematic Diagram

the timing circuit commences to operate, driven by a constant current derived from the reference voltage. When the timing circuit has completed its cycle, it resets the gate bistable, inhibiting the operation of the voltage-to-number converter. The output from the three decade counter is then displayed by the digital display until the next signal from the sampling generator.

The Switch and Neon Circuits

The circuits associated with the input attenuator, the mode select switching, and the circuit for the most significant digit of the display are all shown on one circuit diagram, Fig. 2. The function of each of the switches will be described in turn and the neon indicator circuit will be left until last.

The 'Set 912' switch, SA, has three sets of operating contacts. The first, SA4, breaks the return to zero volts path of the input attenuator, to prevent any loading of the standard calibration signal. The second, SA2, switches the standard calibration signal which appears across R21 and R22, to the input of the operational amplifier through the twin T filter consisting of C3, C4, C5, R14, R16 and R18. This filter, which is tuned to 50Hz, provides 30dB of attenuation to 50Hz signals on any voltage fed to the amplifier.

The polarity switch, SB, has three sets of operational contacts. Two of these, SB1 and SB3, are arranged as a double pole change-over switch which may connect either of the front panel input terminals to the input attenuator, the other terminal being connected to the zero volt line. The third contact, SB4, connects the zero volt line to the neon which indicates the positive terminal.

The 'Set 005' switch, SC, has three sets of working contacts. Two sets, SC2 and SC3, work in series with contacts of SA and perform the same functions. The third set, SC4, connects the input of the twin T filter to a very small reference voltage to give a display, when the digital voltmeter is correctly set, of 005.

The range selector switches, SD, SE, SF, and SG, connect the voltage to be measured to various points on the input attenuator chain, and adjust the attenuation to suit the range selected. The operation of the various switches is as follows:

a) The 1 volt range is selected by SD. The input signal is connected through SD4 directly to the twin T filter through contacts SA2 and SC4. SD3 disconnects the attenuator return paths through R28 and R29, from the zero volt line while SD1 connects the neon N4 to the zero volt line to bring up a decimal point between the first and second digits of display.

b) The 10 volt range is selected by SE. The input signal is connected to the input attenuator through SE4 at the junction of R19 and R17, thus the upper limb of the attenuator is formed by R19, R20, R23, R26, R27, and VR30, the two resistors of the twin T filter R14 and R18, and the amplifier input resistors R13 and R12. The lower limb of the attenuator consists of R15 connected to the zero volt line through SE2.

c) The 100 volt range is selected by SF. This connects the input signal to the input attenuator at R17, and the upper limb of the attenuator consists of R17, R19, R20, R23, R26, R27 and VR30 in series. The lower limb of the attenuator consists of R28 and VR24 in series. The attenuated signal is connected from the junction of VR30 and R28 through SA2 and SC4 to the twin T filter and thence through R13, SF3, SC3, and SA3 to the input of the amplifier.

d) The 1000 volt range is selected by SG. The input signal is connected through SG2 to the top end of the attenuator, and the upper limb of the attenuator is as for the 100 volt range. The lower limb of the attenuator, selected by SG4, consists of R29 and VR25. The attenuated signal taken from the junction of VR30 and R29 is connected to the amplifier through the twin T filter, R12 and R13.

The negative feedback for the amplifier is connected through VR11 and R10 to the zero volt line. When 'Set 912' is selected, the amount of negative feedback may be adjusted by VR11 to set the gain of the amplifier to the required level.

When 'Set 005' is selected, the potentiometer VR9, which is connected between a positive and a negative reference potential, provides a small adjustable offset voltage to the summing junction of the amplifier. This offset voltage is set to obtain a reading of 005 on the digital display.

The most significant digit of the display will either show blank or 1. This is controlled by the pnp/npn pair VT1 and VT2. At the commencement of each digitising cycle, the emitter of VT2 is open circuit by the reset transistor VT13 in the voltage-to-number converter. Thus, the collector of VT2 moves positive towards a potential determined by the potential divider R5, R6. VT1 and VT2 are then cut off, with the base and emitter of VT1 at +4·7V. A positive-going carry signal from the most significant decade of the counter will be coupled through C1 to the base of VT2, which will conduct, causing the neon, N1, to strike and provide a figure 1 in the first window of the display. The collector of VT2 will move negative towards zero volts, reducing the base potential of VT1 below +4·7V. VT1 will then conduct, holding the base of VT2 positive of its emitter.

The change in potential at the base of VT1 provides an enable signal to a two input AND gate operating on logic '0' signals. The second input to this AND gate is taken from the second decade of the counter on the carry propagate line and will move negative when the count reaches 9. Thus, when the display shows 1090, both inputs to the AND gate are at zero volts, providing a signal to reset the bistable in the voltage-to-number converter, inhibiting its operation.

The Operational Amplifier Circuit

The operational amplifier circuit is shown on Fig. 4. The input signal voltage from the attenuator is coupled through PL3-6 and the input resistor R1 to the summing junction of the amplifier. The signal is chopped by the transistor VT1 which is alternately saturated and cut off at 100Hz by a chopper drive signal on its base from the power supplies. The resultant ac signal is amplified by two feedback pairs in cascade (VT2, VT3 and VT4, VT5). The output from the collector of VT5 is coupled through C9 to the second half of the chopper VT6.

This transistor is also alternately saturated and cut off by the chopper drive signal from the power supply, to generate a unidirectional signal which is smoothed in R19, C10 and C11. The resultant dc signal is fed to a long tailed pair, VT7, VT8, which has a high dc gain, but due to the coupling between the bases through C12 and C13, has a low ac gain. The dc output is taken from the collector of VT8 through the inverter VT9 to provide a smoothed negative-going signal for the voltage-to-number generator.

Negative feedback is taken from the voltage-to-number converter to the input of the amplifier through R2, and a dc offset voltage is fed into the summing junction through R3 and R4.

Voltage-to-Number Converter *

The voltage-to-number converter, the circuit of which is shown in Fig. 5, contains two timing circuits having identical configurations. These two circuits are coupled electrically and thermally so that any drifts introduced into one must also appear in the other. One of these timing circuits determines the gating time, while the other provides the conversion from voltage to frequency, the two together being a voltage-to-number converter. Considering the circuit which generates the timing waveform, this consists of transistors VT2, VT3, VT5, VT6 and the associated components. VT2 is a constant current generator which will charge C1 linearly. The rising voltage across C1 will be coupled through MR2 to the emitter of VT5. VT5 and VT6 form a pnp/npn pair which are cut off during the charging period. When the emitter potential of VT5 rises to its base potential, the two transistors will switch regeneratively to a conducting state and discharge C1. The magnitude of current drawn causes the potential at the emitter and the base of VT5 to drop rapidly ; the base then recovers to its normal potential determined by the divider R13 and R14, cutting off the pnp/npn pair.

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* The circuit of the Voltage-to-Number Converter is the subject of Provisional Patent Application No. 27898/67.

The current through the pair causes a positive voltage step across R11 which is coupled to the base of VT3, causing this transistor to conduct and so providing a second discharge path for C1 through R8 and VT3.

The transistors VT1, VT4, VT8 and the zener diodes MR1 and MR3 provide the stable reference voltage from which VT2 draws its charging current. The reference voltage is developed across MR1, and for stability, the current in this zener is held constant by VT4, R9 and MR3. MR3 operates at near constant current controlled by the transistor VT8 which has its base referred to the stable reference potential across MR1. This reference voltage is developed across R3 to give an accurate reference current into C1. The base emitter potentials of VT1 and VT2 are equal and self-compensating to temperature changes.

The second timing circuit is similar in most respects to that already described;the timing capacitor C7 is charged through VT16 and the charging current is determined by the signal voltage applied to the base of VT14 from the chopper-amplifier. To ensure linearity, the transistors VT14 and VT16 are included in the amplifier feedback loop, the feedback signal being taken across R35 and R39 in parallel.

The pnp/npn pair which switches the circuit is VT18 and VT19, while the discharge transistor is VT17 in series with R41. The variable resistor VR37 alters the magnitude of the discharging current and enables the voltage-to-number relationship of the circuit to be linearised. Output pulses are taken from the junction of C7 and R36 through the differentiating circuit C8, R40, and the diode MR7, to drive the three decade counters.

The gate bistable consists of VT10 and VT11. During the display period, this bistable is operating with VT10 saturated and VT11 cut off, thus current flows through R42 and MR9, holding the discharge circuit of C1 in continuous conduction. The collector of VT11 is then approximately −11V, causing a current to flow through R48 and MR11, keeping VT19, VT18 and VT17 in the conducting state. Thus, both sections of the timing circuit are inhibited.

A sampling pulse is coupled through C3 to set the bistable in its reverse state in which VT10 is cut off and VT11 conducts. Thus, the potential at the base of VT5 is permitted to rise, and C1 commences to charge, whilst the collector of VT11 moves to −20V, and the voltage-to-number circuit is permitted to operate.

When, at the end of the timing pulse, VT5 and VT6 switch to conduction, potential fall at the base of VT5 resets the gate bistable to inhibit the timing circuits during the display period.

A sample pulse is taken from a multivibrator consisting of VT7, VT9 and VT12. The main time constant consists of C4 discharging through R18 to an aiming potential determined by the setting of VR20. This is the sampling time control on the front panel, which when turned to its negative position, will hold VT12 permanently cut off so that the last sample is displayed until the sampling time control is again turned to start the sampling time multivibrator.

At the end of a display period, the sampling time multivibrator changes state and an output pulse is taken from the collector of VT12 through VT13 to reset all the decade counters to zero; the time constant in this state is short, determined by C5 and R25, and the multivibrator rapidly resumes the display state. An output pulse is then taken from the collector of VT7 to trigger the gating bistable, permitting a sample to be taken and displayed until the end of the sampling pulse. In the event that the input voltage is greater than the full house capacity of the counters, an overload signal is fed back from the counters to the base of VT15. This cuts off VT15, giving a positive pulse through C6 to reset the gate bistable and stop the operation of the timing circuits.

The Decade Counter Board *

The decade counter consists of a series of npn/pnp pairs connected in cascade as a 'ripple-through' counter. In each case the npn transistor of the pair is also used as the driver transistor for the particular number cathode of the neon indicator tube. Thus a simple circuit has been obtained using low cost components and no diode decoding matrices are required.

The circuit schematic of the decade board is shown in Fig. 7. Since the circuits of most of the npn/pnp pairs are identical, the operation of the first, second, and last only will be described.

The counter is reset by the monostable circuit VT1, VT2. The emitter of VT1 is returned to zero volts through transistor VT13 on the voltage-to-number conversion circuit. This transistor is normally conducting, and is cut off when reset is required. This cuts off VT1, causing its collector to move positive towards 4·7V, so that the base of VT2 moves positive and VT2

* The circuit of the Decade Counter is the subject of Provisional Patent Application No. 27897/67

conducts in saturation. This causes the 'drive input 2' line to move negative to +0·5V, and therefore cuts off all the npn/pnp pairs. These are held off long enough for all the time constants throughout the chain to discharge.

At the end of the reset period, when VT1 returns to conduction, VT2 will be cut off and the 'drive input 2' line will move positive towards 4·7V. The bases of all pnp transistors in the counting chain, with the exception of VT3, will be at +4·7V. The base of VT3, however, is held at a potential between 4·7V and zero volts by the potential divider R6, R7. Thus, VT3 will conduct, switching on VT4 in saturation. The neon indicator will then show zero and the potential of the emitter of VT3 will be half a volt positive of its base potential.

When a negative-going trigger signal is applied to the counter on the 'drive input 2' line, the monostable triggers, causing the emitter of VT3 to move negative below its base potential, cutting off VT3 and VT4. The collector of VT4 will then move positive. The positive-going signal at the collector of VT4 is coupled through C3 and R11 to the base of VT6, which commences to conduct in saturation, causing the figure 1 to show on the neon indicator. The collector potential of VT6 then falls to approximately +0·5V and as the monostable resets, VT5 comes into conduction, holding the base of VT6 positive so that the circuit conducts. Except during the reset pulse, the time constant of the monostable is determined by C2, R3, and is too short for the coupling time constants through the counter to discharge.

The next negative-going input signal on 'drive input 2' will cause a similar sequence. The emitter of VT5 is driven negative by the monostable and ceases to conduct, so that its collector and the base of VT6 move negative towards −4·7V. This cuts off VT6 and its collector moves positive, conveying a trigger signal to the next pnp/npn pair.

Successive trigger signals on the 'drive input 2' line will cause the energised pair to ripple through the counter until the 9 stage is reached. When the 9 stage is cut off by the monostable, the resultant positive-going signal from the base of VT21 is used as a carry propagate signal for the next counter. The carry signals are fed into the ensuing decade on 'drive input 1', causing the monostable to change state.

Thus, the least significant decade receives input signals on 'drive input 2' from the voltage-to-number converter, whilst the other two decades receive carry signals from the previous decade on 'drive input 1'. The carry output from the most significant decade operates a bistable circuit to bring up a 1 in the most significant window.

The Power Supplies

The power supplies for the digital voltmeter, shown in Fig. 9., follow a fairly conventional pattern. The mians transformer primary is tapped for working at 240V, 220V, 115V, or 110V. A 0-225V secondary is half-wave rectified by MR3 into the reservoir capacitor C1. This gives a 257V line for the neon display tubes; a +75V line, also required for the neon display tubes, is developed from the 257V line through R3 and the zener diode MR7.

The centre-tapped 28V secondary feeds two full-wave rectifier circuits, one giving a +20V supply through MR4 and MR5, smoothed by R2 and C2, and the other giving a −20V supply through MR1 and MR2, smoothed by C3. A zener diode MR6 is connected in series with the smoothing capacitor C2 and generates a rectangular waveform from the charging current at 100Hz to provide the chopper drive voltage for the input amplifier. A zener stabilized line at +4·7V is obtained across MR8 through R4.

The +20V line is drawn through the series stabilising transistor VT3. This is controlled by a single stage amplifier VT5 which is referred to the zener diode MR13 and receives error signals from the +20V rail through the potentiometer R16, R17. VT1 is a constant current transistor, the base potential of which is stabilized by the zener diode MR10. This transistor provides a high dynamic load for VT5 to give the maximum effective gain.

The stabilising circuit for the −20V supply is similar, but includes two series stabilising stages to carry the extra current. The amplifier stage VT7 is referred to the zener diode MR14, and receives error signals from the −20V line through the potentiometer R19, R20. The constant current transistor VT2 provides a high dynamic load for VT7; its base potential is stabilized by the zener diode MR11. A −4·7V zener stabilized supply is obtained from MR9 through R5.

5. MAINTENANCE

General

The information provided in this section will assist in locating faults should they develop; it also gives the correct method for assembling and removing printed circuit boards from the instrument. The setting-up procedure will enable the customer to recalibrate his instrument after corrective maintenance.

All the sub-assemblies within the instrument are replaceable, and Weir Electronics Limited offer a replacement service as the most rapid means of instrument repair.

Dismantling Procedure

a) Turn the instrument upside down; extract the four screws holding the case to the base plate. Turn the instrument right side up and move the carrying handle/tilt stand up to the top of the case; carefully lift off the top case assembly.

b) Undo the two 2BA nuts below the attenuator assembly.

c) Undo the two screws holding the mains transformer to the base plate. Feed through the rear panel approximately one foot of the mains cable. Lift and work back from the front panel the assembly of printed circuit boards.

d) With the boards out of the case, the instrument will work with full access for simplified fault finding. The three decade boards are interchangeable and this assists in isolating faults.

e) The unit may be reassembled in its case by reversing the above procedure.

NOTE: On no account should the printed circuit sockets be strained sideways, e.g., by removing or inserting decade boards while the rest of the assembly is in the case. A sideways strain is liable to result in intermittent contact.

Setting-up Procedure

1. The setting-up procedure given here describes the steps required to adjust the preset controls of the instrument. The equipment required to perform these tests consists of one accurate digital voltmeter (0·05% or better) and stable power supplies providing up to 1000 volts. An attenuator may also be required to obtain voltages below one volt.
2. Switch on the instrument and allow thirty minutes for it to reach thermal stability.
3. If corrective maintenance has been carried out on the reference voltage circuits, or a new amplifier board has been fitted, the reference voltage will probably have changed from that shown on the front panel label. The voltage must therefore be checked and a new label fitted, if necessary.
4. To measure the reference voltage, proceed as follows:
   Connect an accurate digital voltmeter (0·05% or better) from the reference voltage line (Point A on Fig. 6) to the negative input terminal. Press the 'cal' button; the reading should be between 0·800 and 1·060V. If it differs from the figure shown on the front panel label, a new label marked with the new reference voltage should be fitted.
5. Connect a stable supply, with attenuators if necessary, to deliver voltages from 5mV to 1·1V. Set the supply to deliver 5mV and adjust the 'Set 005' preset until the digital display shows 005.
6. Set the input voltage to 300mV and adjust the 'Set 912' calibration control until the digital display shows 300.
7. Set the input voltage to 1V and adjust the 'linearity' control at the rear of the amplifier board until the digital display shows 1·000.
8. Repeat 5, 6, and 7 to confirm the settings of the 'Set 005', 'Set 912' and 'linearity' controls. If further adjustments are required, 8 may be repeated.
9. Press the 'Set 005' button and, if necessary, modify the value of R39 until the digital display shows 005. This resistor is selected on test; after corrective maintenance, a different value may be required.
10. Press the 'Set 912' button and adjust the 'Set 912' control until the digital display shows the reference voltage measured in 4.
11. Set the input voltage at various levels between 0 and 1 volt and verify the linearity of the digital conversion. The 1 volt range is now correctly set up.
12. Set the input voltage to 10V; select the 10V range on the instrument and adjust VR30 until the digital display shows 10·00.
13. Set the input voltage to 100V; select the 100V range on the instrument and adjust VR24 until the digital display shows 100·0.
14. Set the input voltage to 1000V; select the 1000V range on the instrument and adjust VR25 until the digital display shows 1000.
15. The three preset potentiometers are mounted on the attenuator assembly and are clearly marked 'Set 1000V, 100V and 10V'.

Fault Finding Procedures

The following tests will assist in identifying the printed circuit board on which a fault has occurred:

1. Power Supplies

Check all power supplies and verify that the measured voltage lies within the limits shown in the following table. The monitor points listed are shown on the Component Location Diagrams.

Monitor Point	Nominal Voltage	Tolerance
B	+20V	±7%
C	−20V	±7%
D	+4·7V	±7%
E	−22V	equal to 20V supply +2V ±10%
F	−4·7V	±7%
G	+75V	±7%
H	257V	Nominal

2. Amplifier Chopper Waveform

The normal chopper waveform, which may be examined at point L, is shown in Fig. 6.; any material deviation from this waveform will indicate an amplifier fault condition.

A positive excursion, several times larger than the negative excursion, indicates an offset error.

A very large positive excursion indicates a break in the amplifier feedback system.

A negative excursion will indicate a negative input signal.

3. Table of Faults

Fault	Action
Inaccurate readings, all ranges.	1. Check 'Set 005' and 'Set 912' settings. 2. Check setting of 'linearity' control. 3. Check amplifier chopper waveform. 4. If the above tests fail to correct the error, check the power supply lines. 5. If power supply lines are correct, amplifier or V/N converter is faulty; obtain replacement board.
Inaccurate readings, one range.	1. Check setting of relevant range potentiometer. 2. Check attenuator resistor specific to that range.
Continuously cycling display.	1. Fault will probably be in gating circuits of V/N converter. Obtain replacement board.
Incorrect display.	1. A faulty decade board will spoil the display on all decades greater than the faulty board. Move the suspect board to another position to confirm the fault. Obtain and fit a replacement board.

6. PARTS LIST

The following list includes all replacement parts with circuit references, values and tolerances, where applicable, and part numbers. When ordering, please quote the NAME, TYPE and SERIAL NUMBER of the instrument together with the CIRCUIT REFERENCE and the DESCRIPTION of PART.

Circuit Ref.	Description	Value	Rating	Tol.	Part No.
Switch and Neon Assembly					
VT1	Transistor				Motorola 2N4125
VT2	Transistor				Texas D1533/D1501
MR1	Diode				Texas 1N660
N1	Neon				Hivac 23L
N2, 3, 4, 5, 6	Neon				R.G.F. Elect. MN500
R1, 6	Resistor C.F.	100k	½W	5%	Piher WP051
R2	Resistor C.F.	1k	½W	1%	Piher WP051
R3	Resistor C.F.	10k	½W	5%	Piher WP051
R4 *	Resistor M.F.	10M	1W	1%	Morganite FC70
R5	Resistor C.F.	120k	½W	5%	Piher WP051
R7, 8	Resistor C.F.	430k	½W	5%	Piher WP051
C1	Capacitor	360pF	125V		Suflex HS
C2	Capacitor	82pF	350V	2%	Lemco 316
Filter and Switch					
R10	Resistor C.F.	5·1k	½W	2%	473-1
R21	Resistor C.F.	1M	½W	2%	473-1
R22	Resistor C.F.	4·7k	½W	5%	471-1-4·7k
VR9, 11	Trim Pot.	1k		5%	M.E.C. Ltd. MP32
SA, SB, SC	3 Button Switch				A.B. Metals Ltd. 3/400/026(4000)
Filter and Switch P.C.B.					
R12 *	Resistor M.F.	101k		1%	Morganite FC65
R13 *	Resistor M.F.	259k		1%	Morganite FC70
R14, 18 *	Resistor M.F.	320k		1%	Morganite FC70
R16	Resistor M.F.	160k	½W	2%	Electrosil TR5
C3, 5	Capacitor	10,000pF	1000V	2½%	Waycom MAIL611
C4	Capacitor	20,000pF	1000V	2½%	Waycom MAIL611
Pre-attenuator P.C.B.					
R15, 19 *	Resistor M.F.	1M		1%	473-1-1M
R17, 20, 23, 26 *	Resistor M.F.	2.2M		1%	Morganite FC70
R27 *	Resistor M.F.	150k		1%	473-1-150k
R28 *	Resistor M.F.	99k		1%	473-1-99k
R29 *	Resistor M.F.	9·8k		1%	473-1-9·8k
VR24 *	Preset Pot.	5k		1%	Iskra PN10B
VR25 *	Preset Pot.	500		1%	Iskra PN10B
VR30 *	Preset Pot.	500k		1%	Iskra PN10B
Amplifier					
VT1	Transistor				Mullard BCY70
VT2, 3, 4, 5	Transistor				Micro-Electronics ME4003
VT6	Transistor				Mullard BCY33
VT7, 8	Transistor				Motorola 2N4124
VT9	Transistor				Motorola 2N4126
MR1, 2, 5	Diode				482-2
MR3, 4	Zener Diode				481-4V7-1

Circuit Ref.	Description	Value	Rating	Tol.	Part No.
Amplifier Cont.					
R1, 2	Resistor M.O.	100k		1%	Electrosil NC5
R3, 4	Resistor C.F.	5·6M	½W	10%	471-1-5M6
R5, 12, 18, 21, 22	Resistor C.F.	10k		5%	471-1-10k
R6, 13	Resistor C.F.	15k		5%	471-1-15k
R7	Resistor C.F.	2·2k		5%	471-1-2k2
R8, 14, 23	Resistor C.F.	100k		5%	471-1-100k
R9, 15	Resistor C.F.	150k		5%	471-1-150k
R10, 16, 19, 20, 24, 27, 29, 30	Resistor C.F.	1k		5%	471-1-1k
R11, 17	Resistor C.F.	220k		5%	471-1-220k
R25	Resistor C.F.	12k		5%	471-1-12k
R26	Resistor C.F.	820		5%	471-1-820
R28	Resistor C.F.	47k		5%	471-1-47k
R31	Resistor C.F.	1M		5%	471-1-1M
C1, 3, 15	Capacitor	·01μF			Hunts SLM13 Type 310
C2, 16	Capacitor	·1μF	250V		Mullard C281/AB/A100K
C4, 7, 10, 11, 14	Capacitor El.	50μF	25V		Mullard C426/AR/F50
C5	Capacitor	2:2μF	100V	20%	S.T.C. PMA2·2M100
C6, 8	Capacitor	1000pF	160V	10%	Iskra KSN
C9	Capacitor El.	10μF	70V		Hunts AW1811A00
C12, 13	Capacitor El.	200μF	10V		Mullard C426/AR/D200
V/N Converter					
VT1, 3, 6, 8, 9, 19	Transistor				Motorola 2N4123
VT2	Transistor				Mullard BCY70
VT4, 14, 16	Transistor				Motorola 2N4126
VT5, 15, 18	Transistor				Motorola 2N4125
VT7, 10, 11, 12, 13	Transistor				Motorola 2N4124
VT17	Transistor				Micro-Electronics ME4003
MR1	Zener Diode	6V		2% at 5mA	Semitron Z0B
MR2, 5, 6, 8, 9, 10, 11	Diode				482-2
MR3	Zener Diode				481-4V7-1
MR4, 7, 12	Diode				482-1
R1	Resistor C.F.	150k		5%	471-1-150k
R2, 11, 44	Resistor C.F.	100		5%	471-1-100
R3 *	Resistor M.F.	47k		1%	473-1
R4 *	Resistor M.F.	5·1k		1%	473-1
R5 *	Resistor M.F.	27k		1%	473-1
R6, 43	Resistor C.F.	47		5%	471-1-47
R7, 15, 27, 31, 47	Resistor C.F.	2·2k		5%	471-1-2k2
R8, 41	Resistor C.F.	10		5%	471-1-10
R9	Resistor M.O.	820		1%	Electrosil TR5
R10	Resistor C.F.	470		5%	471-1-470
R12	Resistor C.F.	1k		5%	471-1-1k
R13, 45	Resistor W.W.	680	5W	5%	Radiospares 5W Res.
R14, 46	Resistor W.W.	1k	5W	5%	Radiospares 5W Res.
R16, 51, 52	Resistor C.F.	1M		5%	471-1-1M
R17, 23, 28, 29, 40, 49, 50	Resistor C.F.	10k		5%	471-1-10k
R18, 22, 34	Resistor C.F.	22k		5%	471-1-22k
R19	Resistor C.F.	47k		5%	471-1-47k
R21	Resistor C.F.	39k		5%	471-1-39k
R24	Resistor C.F.	82k		5%	471-1-82
R25, 38	Resistor C.F.	220k		5%	471-1-220k
R26, 32, 42, 48	Resistor C.F.	6·8k		5%	471-1-6k8

Circuit Ref.	Description	Value	Rating	Tol.	Part No.
V/N Converter Cont.					
R30	Resistor C.F.	100k		5%	471-1-100k
R33	Resistor W.W.	2·7k	5W	5%	Radiospares 5W Res.
R35	Resistor W.W.	470	5W	5%	Radiospares 5W Res.
R39	Resistor C.F.	A.O.T.		5%	471-1-x
VR20	Edgewise Pot.	10k LIN			Egen 415G
VR37	Preset Pot.	100			Welwyn P25
C1	Capacitor	2·2μF	100V	5%	S.T.C. PMA2·2J100
C2	Capacitor El.	200μF	10V		Mullard C426/AR/D200
C3, 5, 6, 8, 9	Capacitor	·01μF			Hunts SLM13 Type 310
C4	Capacitor El.	50μF	25V		Mullard C426/AR/F50
C7	Capacitor	·1μF	100V	5%	S.T.C. PMA0·1J100
C10	Capacitor	270pF	160V	10%	Iskra KSN
Decade P.C.D.					
VT1, 2	Transistor				Motorola 2N4124
VT3	Transistor				Motorola 2N4125
VT4, 6, 8, 10, 12, 14, 16, 18, 20, 22	Transistor				Texas D1533/1501
VT5, 7, 9, 11, 13, 15, 17, 19, 21	Transistor Spec.2				Texas D1374
V1	Numerical Indicator Tube				S.T.C. GN6
MR1	Diode				Mullard OA91
MR2, 3, 4, 5, 6, 7, 8, 9, 10	Diode				Texas 1N660
R1	Resistor C.F.	2·2k	½W	5%	Piher WP051
R2, 13, 17, 21, 25, 29, 33, 37, 41, 45	Resistor C.F.	10k	½W	5%	Piher WP051
R3	Resistor C.F.	120k	½W	5%	Piher WP051
R4, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46	Resistor C.F.	68k	½W	5%	Piher WP051
R5, 6, 8	Resistor C.F.	1k	½W	5%	Piher WP051
R7	Resistor C.F.	1·8k	½W	5%	Piher WP051
R9	Resistor C.F.	22k	½W	5%	Piher WP051
R11, 12, 15, 16, 19, 20, 23, 24, 27, 28, 31, 32, 35, 36, 39, 40, 43, 44	Resistor C.F.	4·7k	½W 5%	5%	Piher WP051
R47	Resistor C.F.	68k	1W	5%	Piher WP11
C1	Capacitor	180pF	125V	10%	Suflex H.S.
C2, 4, 6, 8, 10, 12, 14, 16, 18, 20	Capacitor	82pF	350V	2%	Lemco 316
C3, 5, 7, 9, 11, 13, 15, 17, 19	Capacitor	1000pF	125V	10%	Suflex H.S.
Power Supply					
VT1, 6, 7	Transistor				Motorola 2N4125
VT2, 3	Transistor				Motorola 2N4123
VT4	Transistor				R.C.A. 40347
VT5	Transistor				Motorola 2N4124
MR1, 2, 4, 5	Diode				Thorn-A.E.I. BY125
MR3	Diode				Iskra BY237
MR6, 8, 9	Zener Diode				Mullard BZY88C4V7
MR10, 11, 13, 14	Zener Diode				Mullard BZY88C6V8
MR7	Zener Diode				S.T.C. Z3B750CF
MR12	Diode				Mullard OA91

Circuit Ref.	Description	Value	Rating	Tol.	Part No.
Power Supply Cont.					
R2	Resistor C.F.	10	½W	5%	Piher WP051
R3	Resistor C.F.	33k	1W	5%	Piher WP11
R4	Resistor C.F.	680	1W	5%	Piher WP11
R5	Resistor C.F.	1k	1W	5%	Piher WP11
R6, 7, 8, 11	Resistor C.F.	4·7k	½W	5%	Piher WP051
R9, 12	Resistor C.F.	10k	½W	5%	Piher WP051
R10, 14, 18, 22, 23	Resistor C.F.	1k	½W	5%	Piher WP051
R13, 15	Resistor C.F.	47	½W	5%	Piher WP051
R16, 19	Resistor M.F.	4·7k		1%	Electrosil TR5
R17, 20	Resistor M.F.	2·7k		1%	Electrosil TR5
R21, 24	Resistor C.F.	6·8k	½W	5%	Piher WP051
C1	Capacitor El.	32µF	350V		Sprague HD2
C2, 3	Capacitor El.	250µF	64V		Mullard C437/AR/H250
C4, 5	Capacitor	·01µF			Hunts SLM13 Type 310
C6, 7	Capacitor El.	50µF	25V		Mullard C426/AR/F50
C8	Capacitor El.	200µF	10V		Mullard C426/AR/D200
C9, 10	Capacitor	·1µF	250V		Mullard C281/W/100K
T	Transformer Issue 2				Hinchley C5032/55
	Fuse		250mA		Radiospares
Connector P.C.D.					
MR1, 2	Diode				Mullard OA91
C1, 5	Capacitor El.	200µF	10V		Mullard C426/AR/D200
C2, 3, 4	Capacitor El.	50µF	25V		Mullard C426/AR/F50

* These components have a temperature coefficient of 50PPM/°C

Abbreviations:

C.F.	Carbon Film	M.F.	Metal Film	M.O.	Metal Oxide
El.	Electrolytic	W.W.	Wire Wound		

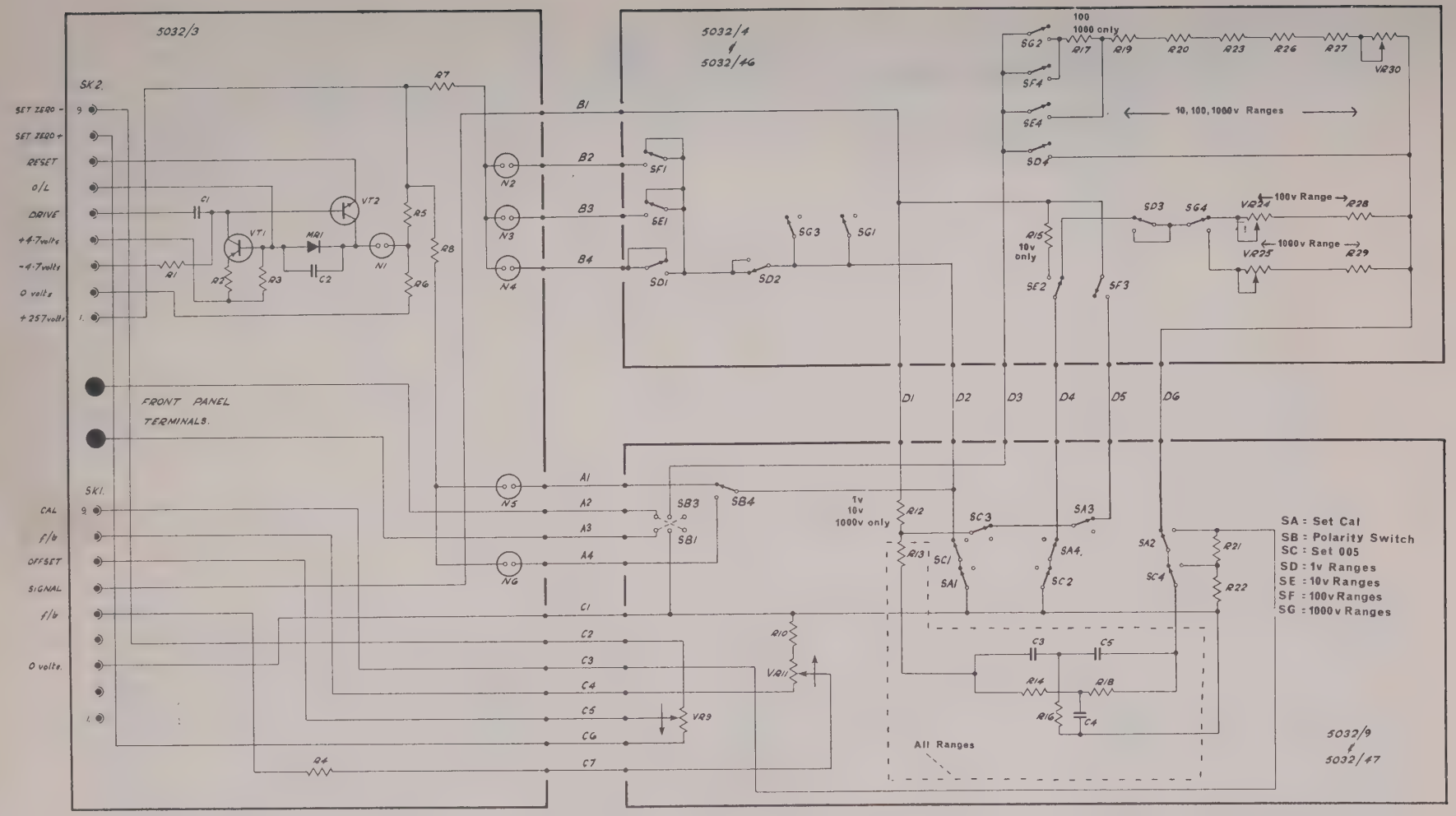


Fig.2. Switch and Neon Circuit Diagram

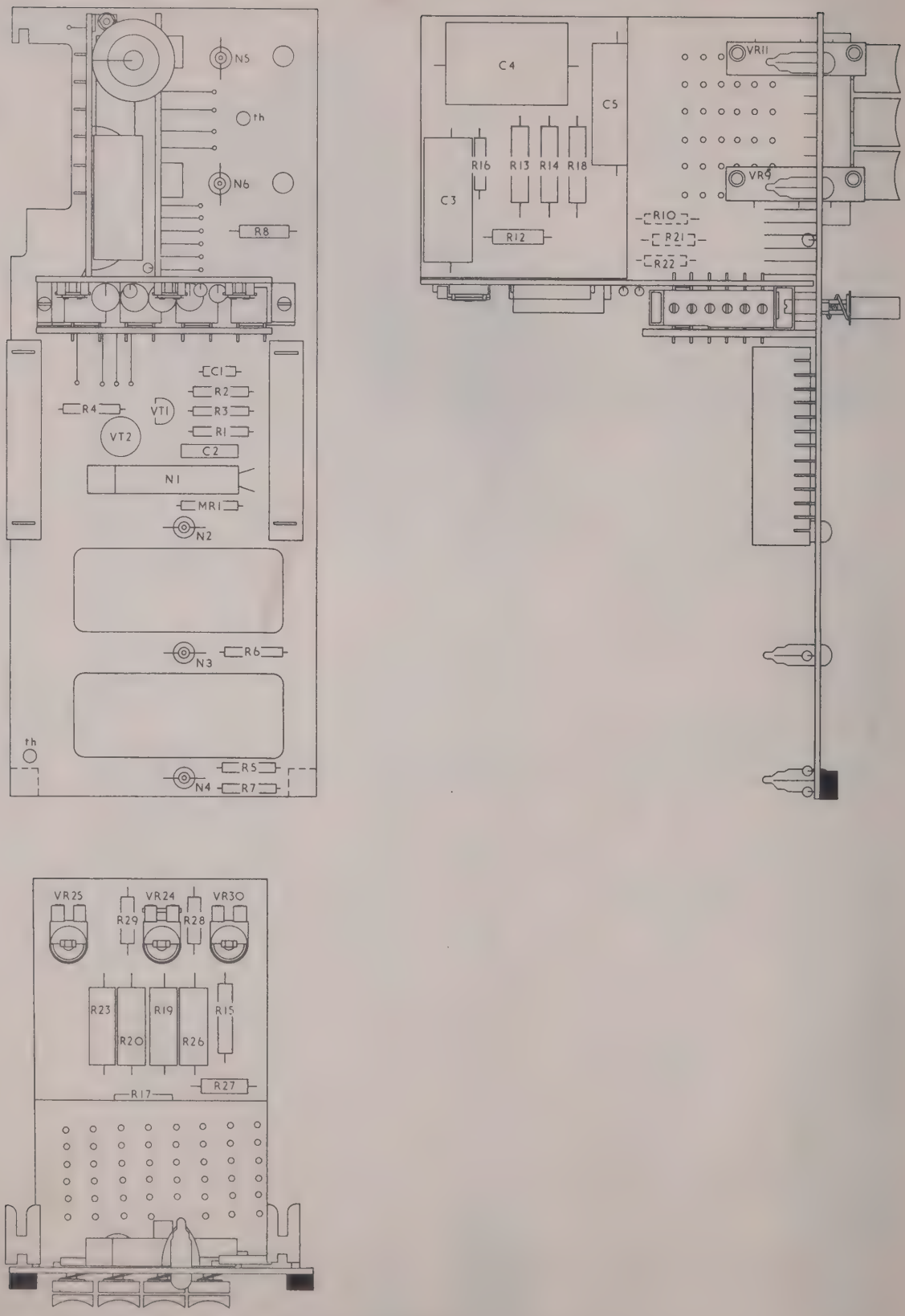


Fig. 3. Switch and Neon Layout Diagram

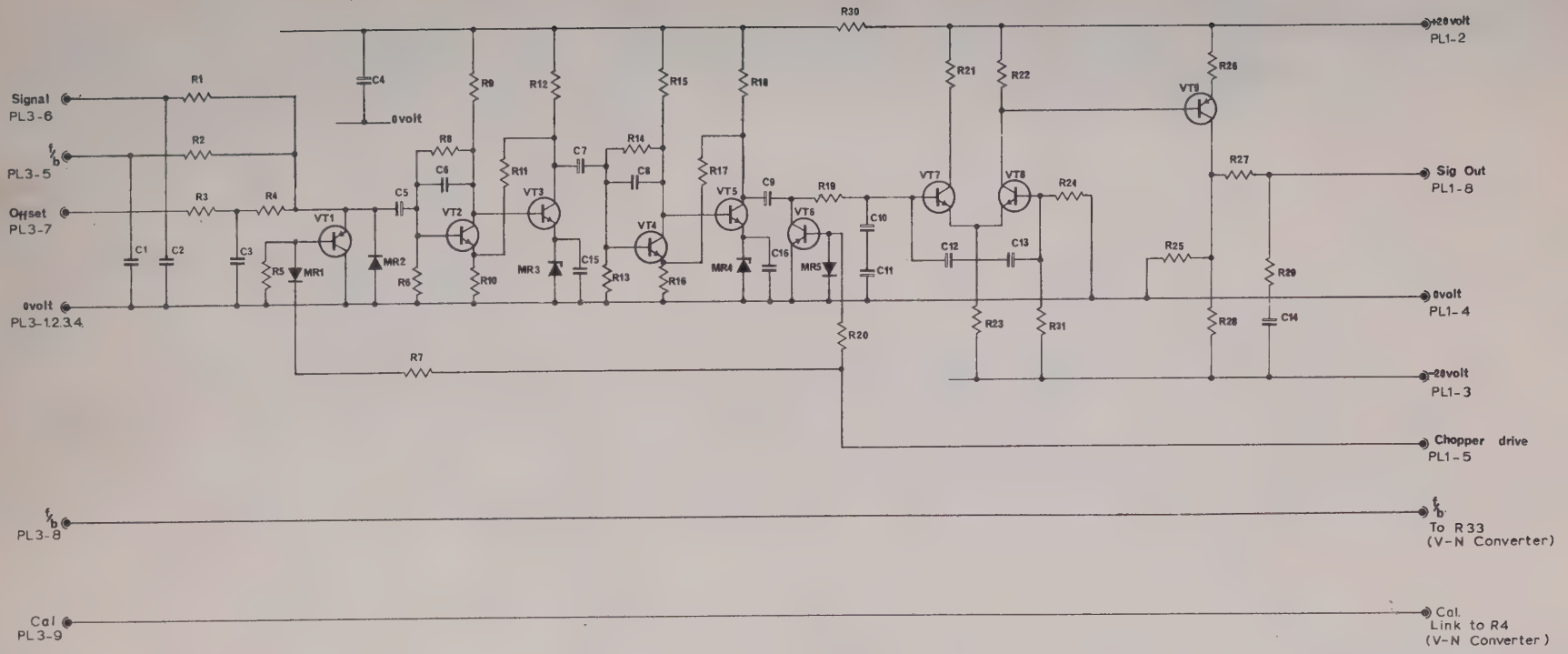
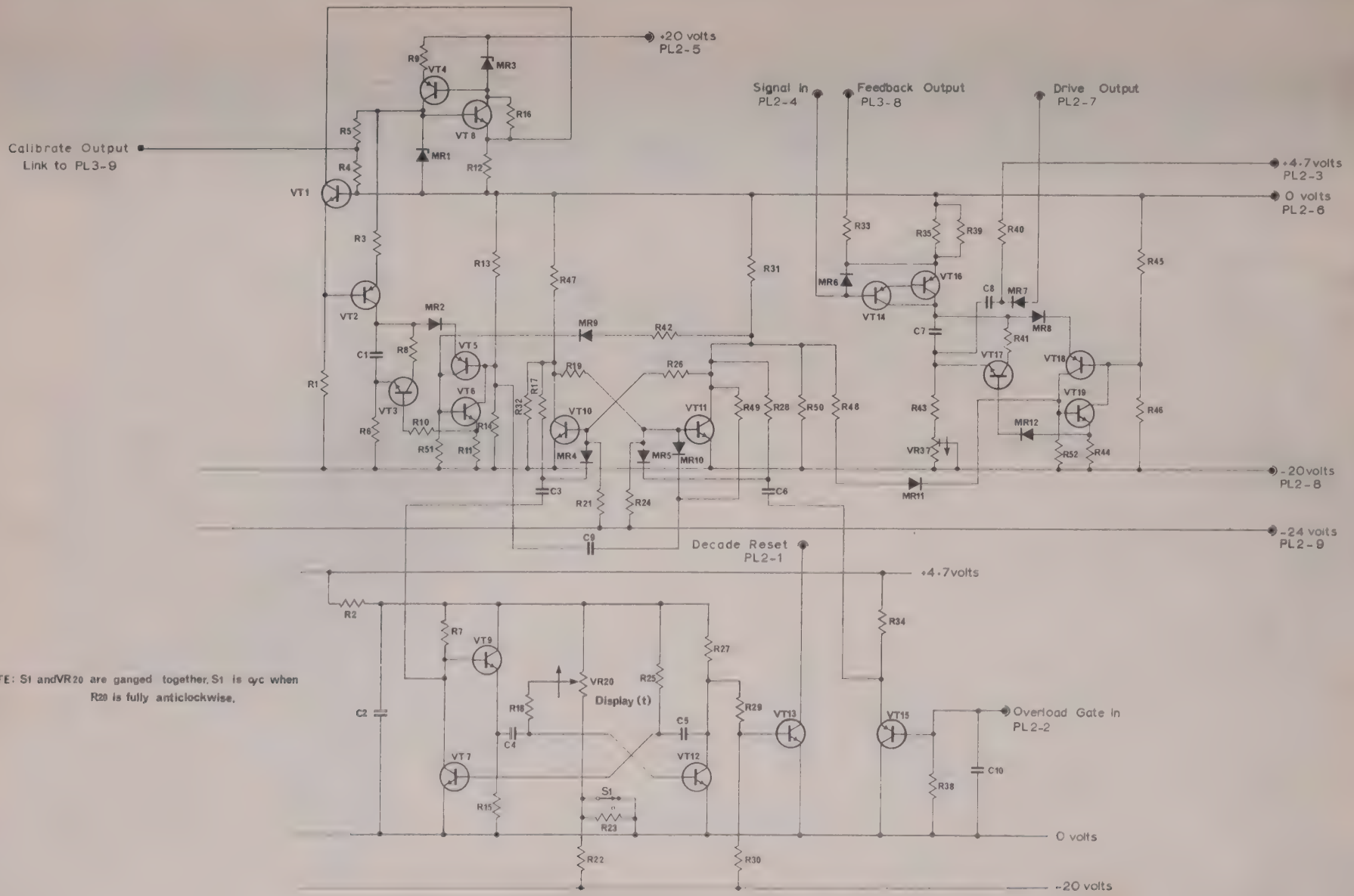
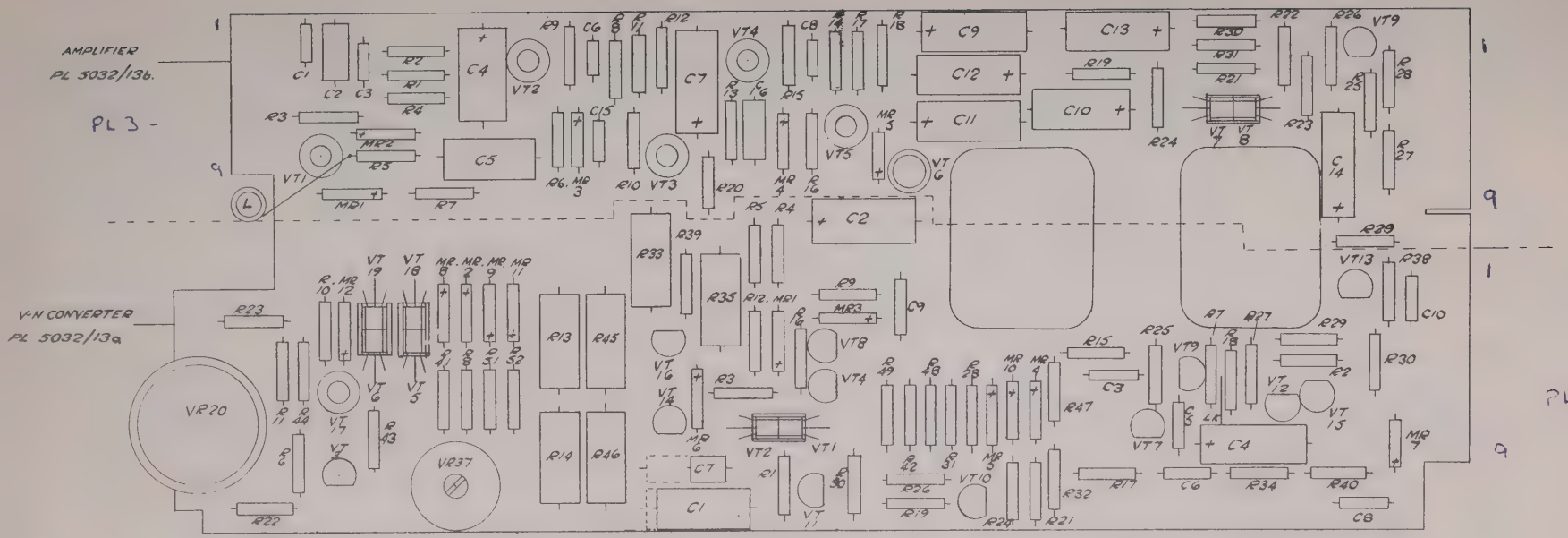


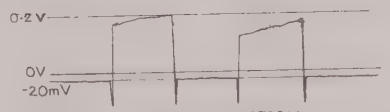
Fig. 4. Amplifier Circuit Diagram



NOTE: S1 and VR20 are ganged together, S1 is o/c when R20 is fully anticlockwise.

Fig. 5. V - N Converter Circuit Diagram





CORRECT CHOPPER WAVEFORM
MONITORED AT POINT L

Fig. 6. Amplifier and V - N Converter Layout Diagram

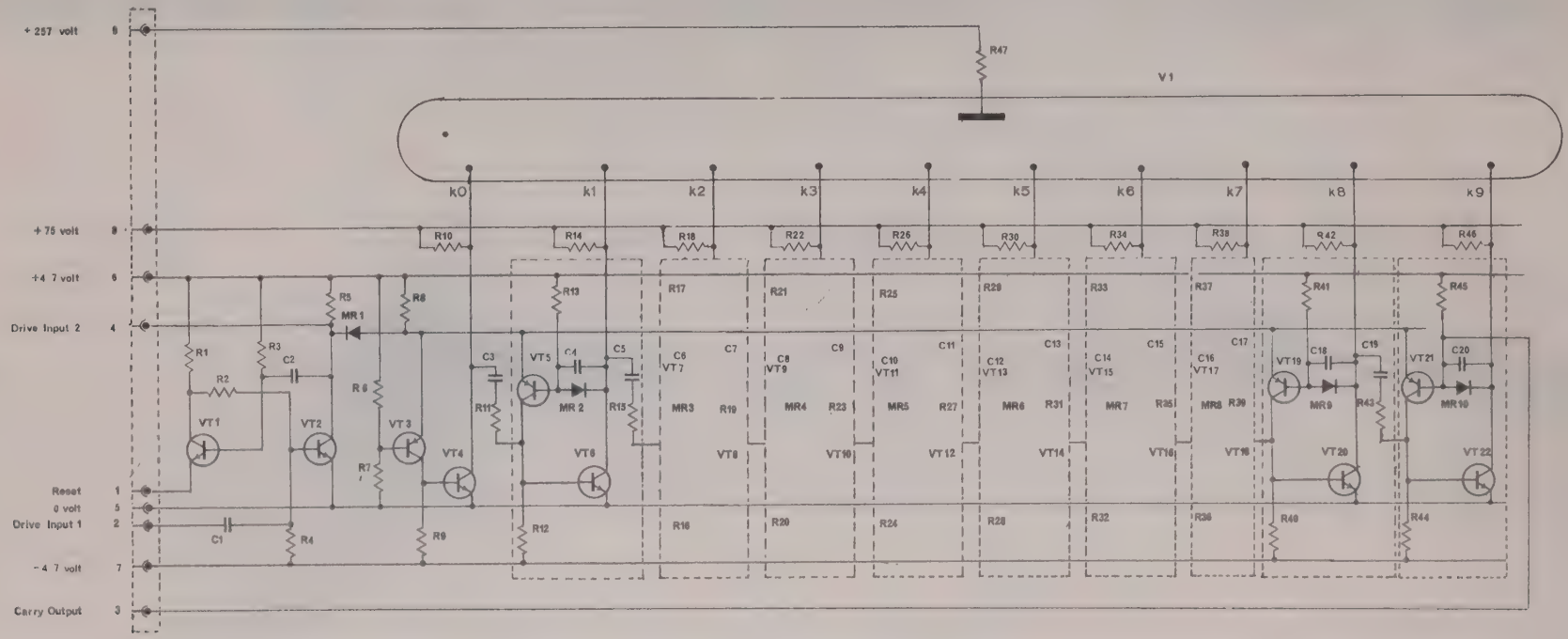


Fig. 7. Decade Board Circuit Diagram

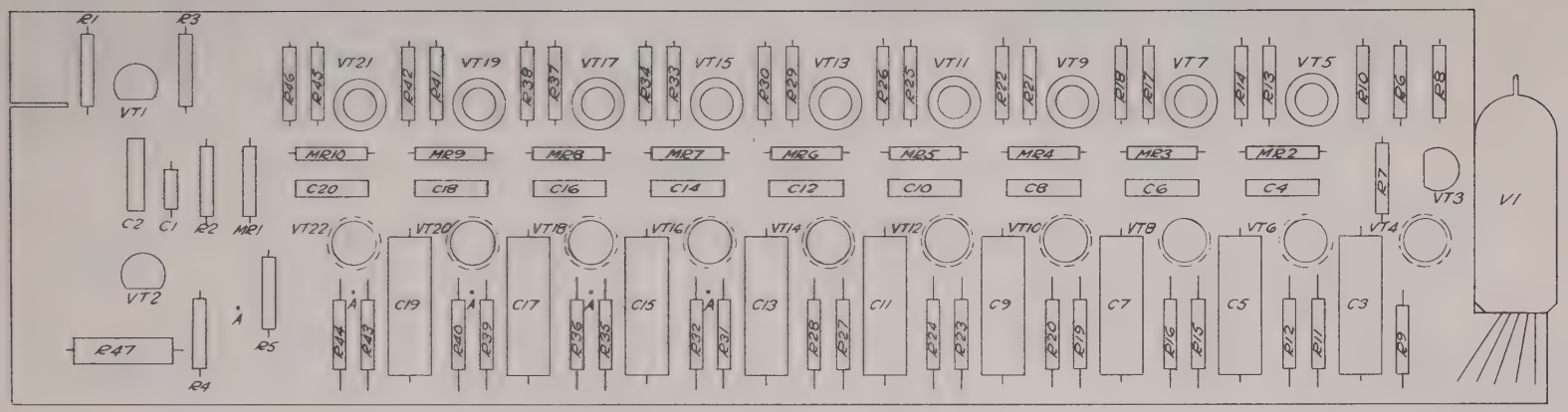


Fig. 8. Decade Board Layout Diagram

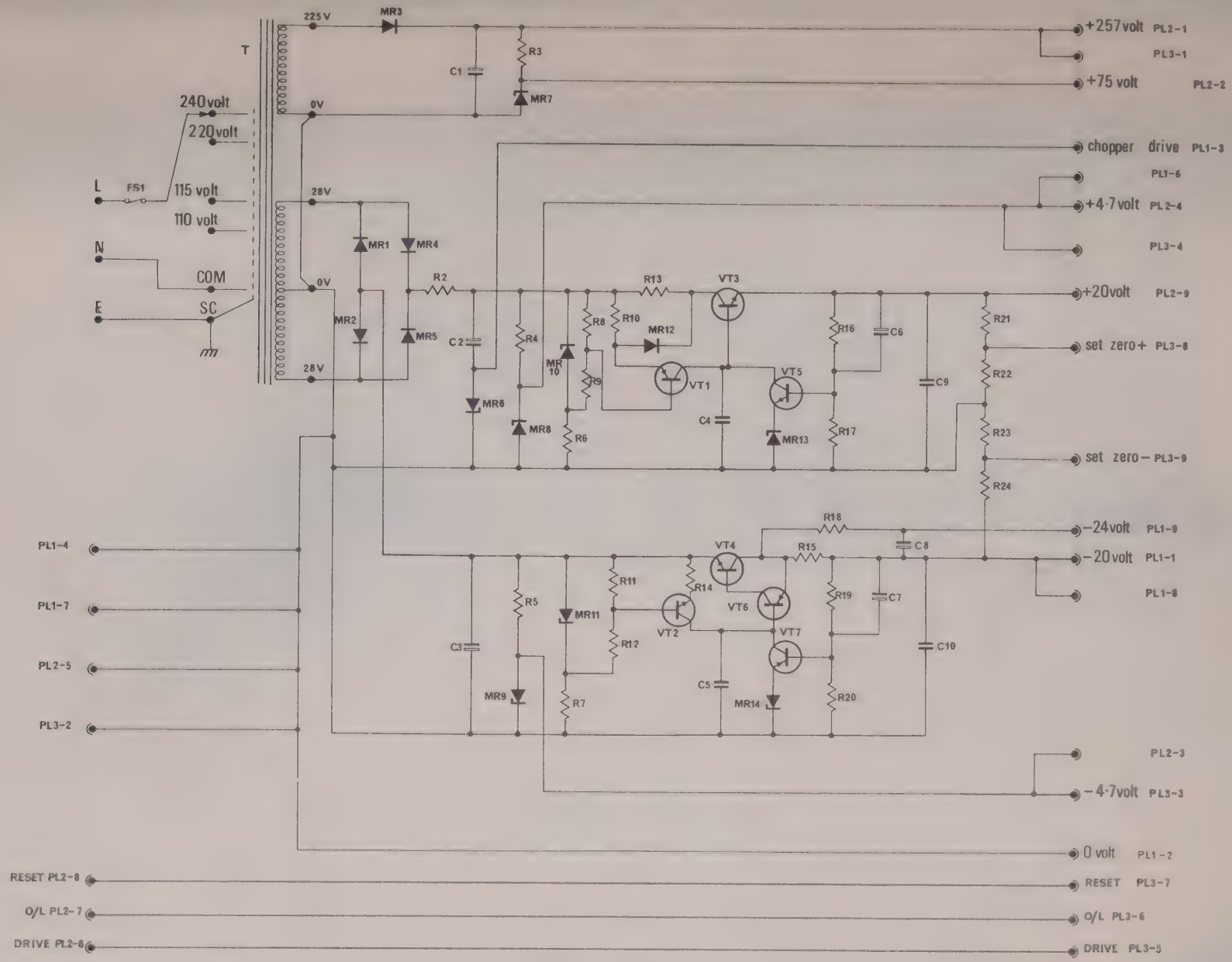


Fig. 9. Power Supplies Circuit Diagram

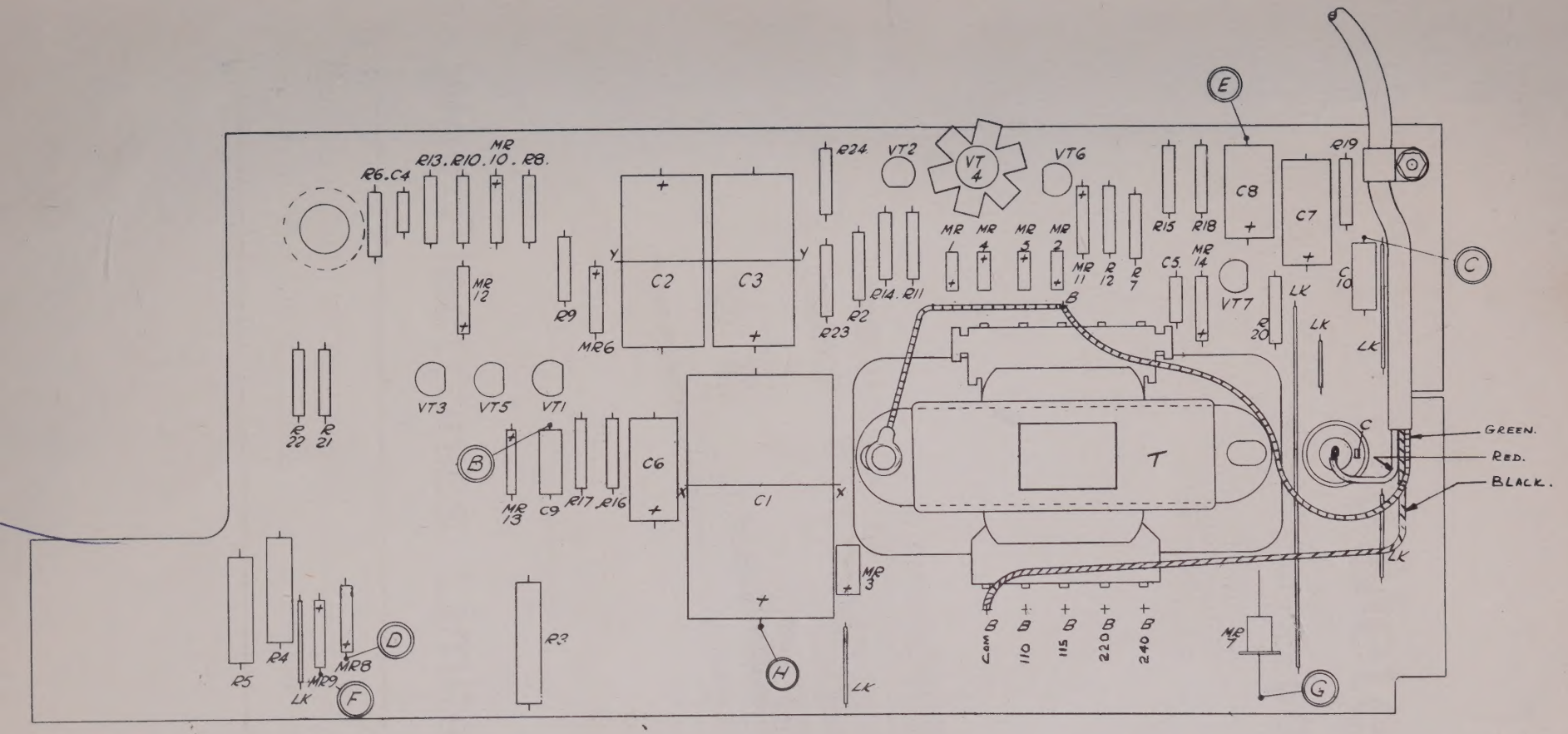


Fig. 10. Power Supplies Layout Diagram

MP MASTER
MA24474